Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary
June 21, 2011
Archdale Building, Raleigh NC

X APPROVED for distribution, August 16, 2011

Attendance

Members
Donnie Brewer, EMC
Bob Christian, NC Marine Fisheries Commission
Tom Cuffney, U.S. Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC Cooperative Extension
Jim Mead, NC Division of Water Resources
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA (via web)
Fritz Rhode, National Marine Fisheries Service
Jay Sauber, NC Division of Water Quality
Bill Swartley, NC Forestry Association

Alternates
Cat Burns, The Nature Conservancy
Vernon Cox, NCDA&CS
Sarah McRae, US Fish and Wildlife Service
Angie Rodgers, NC Natural Heritage Program (via web)
Arlene Roman, City of Gastonia (via web)
Vann Stancil, Wildlife Resources Commission
Holly Weyers, NC Water Science Center

Division of Water Resources
Tom Fransen
Tom Reeder
Don Rayno
Sarah Young

Facilitation Team
Mary Lou Addor, Natural Resources Leadership Institute (NRLI)
Patrick Beggs, Watershed Education for Communities and Officials (WECO)
Christy Perrin, Watershed Education for Communities and Officials (WECO)
Nancy Sharpless, Natural Resources Leadership Institute (NRLI)

Guests:
David Elliot
Jeri Gray, WRRI
Lars Hanson (via web)
S. Kraemer (via web)
Mick Noland (via web)
Michael Paul, Tetra Tech
Jennifer Phalen, RTI
Haywood Phythsic, LNBA/NRCW

The purpose of the Ecological Flows Science Advisory Board:

The Ecological Flows Science Advisory Board will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and background information about the E-Flows SAB are available at:
www.ncwater.org/sab

NOTE: The next meeting of the EF SAB is **12 noon, August 16, 2011 at RTI.**

Quick Summary

June 21, 2011: Decisions Made/Actions to be Taken

A. The May 17, 2011 Meeting Summary was approved and is posted on the website.
B. The Ecological Flows Science Advisory Board asked the Division of Water Resources to move forward with the Eno River demonstration sites for the purpose of modeling, with the caveat that the SAB continue to look at other ways and other sites. (See Section III)
C. The Ecological Flows Science Advisory Board decided which flow schemes to run with the OASIS model, using the Eno River. (See Section VI)

Proposed Actions or Identified Decisions to Be Made

A. Acknowledge high flows but focus on the impacts of water supply and water withdrawals on ecological flows.
B. Acknowledge land use but focus on the impacts of water supply and water withdrawals on ecological flows.
C. Issues to address in characterizing ecological integrity:
    a. How much "disruption" can occur that still allows "recovery"?
    b. What does "comparable to prevailing ecological conditions" mean?
    c. Define balance.
    d. Ecological integrity should account for complexity and for variability in many aspects: thermal, hydrologic, biologic, etc.
    e. What if flow is not the determinant factor supporting ecological integrity in a particular classification of stream? Should this be determined?
    f. Only address aquatic systems?

D. How will monitoring be accomplished?

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I. Executive Summary (This Executive Summary was added by the facilitators in February, 2013)

Debrief of Eno River Demonstration Project (*Jim Mead)*

Jim Mead, NCDWR, provided an overview of the May 17 Eno River State park visit. The process is a 3 legged stool: (1) hydrology (OASIS model), (2) hydraulic models (data collection with flow meters, surveys, to look at channel geometry and how it changes different flows, and (3) habitat models. The EFSAB discussed level of knowledge of how a particular guild, species, or endangered species responds to different depths, flows.

Jim presented a list of guilds and species proposed for inclusion in the Eno River Demo: list of guilds He then invited questions from the EFSAB about last month's discussions at the Eno and the Persinger paper, which looked at guilds, how well different species fit into guilds and how they vary.

Questions, Comments, and Concerns Raised

- **T**he Eno is only one test; we should make our knowledge inferences on more than a single exercise- the potential errors are large.
- I'd like to know if the classification system holds up from a habitat standpoint.
- I encourage you to do invertebrates- if so you should look at some guilds that have been used more for hydrological investigations than what you have now.
- Can you give more info on how these 19 guilds were derived? If you're dealing with the state, in some cases 4 is better than 19. Are we sold on the 19?
- I think it's important there is so much variability; we want to capture all inherent variability in the system rather than look narrowly at four coarse categories.
- I've heard other good comments- about using historic data on macro-invertebrates, and using OASIS to look at flows. Use OASIS to look at groups of streams (small flashy streams in the Neuse for example) with no change, hydrologic alterations, and look at their ratings by NCDWQ macro invertebrate standards. We would have to look at available resources for that approach. Currently my proposal is for the 2 Eno River sites while considering the DWQ data separately.

Proposed Actions or Identified Decisions to be made:

1. **DWR should move forward with demo effort for the 2 Eno River demo sites to produce results and make sure we're analyzing those results correctly. DWR can likely get results in 2-3 months.**

Revisit Scope of EFSAB Work

DWR clarified the scope of the EFSAB and its legislative mandate. Two main points:

1. High flows. It is reservoirs that impact high flow regimes. It isn't the water taken out of streams that impacts high flow; it is this big pool in reservoirs. We can acknowledge the importance of high flows to stream ecology, but not use them to determine flows for ecological integrity. Run-of-river withdrawals and low flow scenarios are more significant in determining ecological integrity. Reservoirs are more suited to case specific permitting as opposed to the planning process the EFSAB is trying to develop.

2. Land use change. It has a huge impact but it is not a part of the legislative mandate for determining ecological flows.

Questions, Comments and Concerns Raised

- Cumulative effects.
    - Regarding high flows and withdrawals, we need to be concerned about cumulative effects.
    - With significant withdrawals, the cumulative impact on high flows may be disregarded if you aren't looking at high flows.
    - If we put a lot of effort into coming up with ecological flows, we can't just say that it won't work if there are changes in land use or development of new reservoirs. We may need to say that if you do develop this land, specific changes will take place to ecological flows.
    - We need to define when a reservoir is a run of river reservoir and when it is separate.
- Land use:
    - We may need to say that if you do develop this land, specific changes will take place to ecological flows.
    - We should include land use in the modeling since available water depends on land use.
    - Land use issues should not be the focus of the EFSAB.
    - The accommodation of land use and its effect on ecological flow is being done in the hydrological modeling, in terms of predicting future conditions. In terms of water availability, for water supply and instream, we need to have an idea of total water availability for future land use changes. So we need to be able to accommodate that in our model from the standpoint of how much water is there to work with. If we did not do this we would be lacking in our approach.
    - Incorporating information into the modeling is a good idea but making recommendations about land use for the study is not.

Proposed Actions or Identified Decisions to be made:

1. Acknowledge high flows but focus on the impacts of water supply and water withdrawals on ecological flows.
2. Acknowledge land use but focus on the impacts of water supply and water withdrawals on ecological flows.

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What Does Ecological Integrity Mean to You

The legislation that mandated the formation of the EFSAB tasked the EFSAB with assisting the Department of Environment and Natural Resources (DENR) in characterizing the ecology in the different North Carolina river basins and identifying the flow necessary to maintain *ecological integrity*. The legislation defines ***ecological integrity*** as **"the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to prevailing ecological conditions and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system."** Although the legislation provides a definition, and the EFSAB must work with that definition, different EFSAB members may have different interpretations of that definition, and members may have differing views and opinions on what *ecology integrity* encompasses. In order to increase understanding among the EFSAB members of how they look at and interpret ecological integrity, as they work toward reaching consensus in identifying the flow necessary to maintain ecological integrity, the facilitators invited the individual EFSAB members to consider how their own definition of ecological integrity might differ, if at all, from the legislative definition.

Proposed Actions or Identified Decisions to be made:

1. **Issues to address in characterizing ecological integrity:**

    a. How much "disruption" can occur that still allows "recovery"?
    b. What does "comparable to prevailing ecological conditions" mean?
    c. Define balance.
    d. Ecological integrity should account for complexity and for variability in many aspects: thermal, hydrologic, biologic, etc.
    e. What if flow is not the determinant factor supporting ecological integrity in a particular classification of stream? Should this be determined?
    f. Only address aquatic systems?
    g. How will monitoring be accomplished?

Flow Scenarios with Chris Goudreau

link to presentation

Chris Goudreau of the NC Wildlife Resources Commission presented an Introduction to Flow Scenarios. He noted a range of options for e-flows:

- No Protection - No legal ability to keep from drying up the stream. This is rare in NC, but there are examples.

- Threshold Protection / Minimum Flow - This may be a single value, such as the 7Q10 or it may be a seasonal value (eg. 20/30/40 percent of MAF)
- Partial Ecologically-Based Protection - This addresses 1-4 riverine components. There are 5 components: hydrology, biology, water quality, connectivity, geomorphology. The most likely to be addressed in this scenario are hydrology, biology and water quality. In addition, this scenario may address intra-annual variability, but not inter-annual variability.
- Comprehensive Ecologically-Based Protection - addresses all 5 riverine components and maintains intra-annual and inter-annual variability.
- Full Protection (hands off) may be seen in wilderness areas or other things that are set aside for other reasons.

- General Approaches (Richter et al. 2011)

    - Minimum Flow Threshold (basically the 7Q10 concept)
    - Statistically-based Standard
    - Percent of Flow Standard

    DWR will run the model under different flow regimes, gathering data for each regime. The EFSAB needs to help DWR determine which flow regimes to run. Examples of flow regimes include 7Q10, percent of water removed, percent of water retained in stream, based on total, or based on previous measurement, or based on mean annual flow. It was noted that many of the factors such as spawning data is not germane to the habitat model the EFSAB will be using.

Questions/ Comments/Concerns Raised:

- We use the habitat curves as a surrogate for the biology. We make assumptions and say, this type of habitat supports this type of biota.

- It is important to know the changes in the graph, the thresholds where things change. If the outputs are all linear graphs, it is easy to make assumptions. We need to know at what flow regimes things change.

- The 7Q10 is such an old standby that we need to include it as one of the inputs.

- What about the source of the water, for example, wastewater discharge may account for a large portion of flow during dry seasons? Water sources will not impact the model output.

II. Welcome, Agenda Review and introductions

Christy Perrin, facilitator, welcomed everyone to the fifth meeting of the Ecological Flows Science Advisory Board (EFSAB). Attendees introduced themselves. Christy reviewed the agenda.

III. Review June 21, 2011 Meeting Summary

The May 17, 2011 meeting summary was approved and is posted on the Ecological Flows SAB website. [www.ncwater.org/sab]

IV. Debrief of 15 Eno River Demonstration Project from May 17 fieldtrip

Jim Mead, NCDWR, provided an overview of the May 17 Eno River State park visit. The process is a 3 legged stool: (1) hydrology (OASIS model), (2) hydraulic models (data collection with flow meters and surveying equipment, to look at channel geometry and how depth and velocity change at different flows, and (3) habitat models. The EFSAB discussed level of knowledge of how a particular guild, species, or endangered species responds to different physical conditions (depth, velocity, substrate).

NCDWR sent 2 readings about guilds and species via email before this meeting. One is an Excel file with a list of guilds and species proposed for inclusion in the Eno River Demo. When the studies were done 25 years ago, Division of Water Resources (DWR) modeled redbreast sunfish life stages. More information about biological preferences is now available. DWR proposes modeling the habitats of 19 more species/life stages, drawn from their hydropower license experience. Species from the expanded list that are irrelevant for the Eno will be dropped (brown trout for example).

The other was a paper by Persinger et al. 2010. They looked at guilds, and how well different species fit into guilds and how they vary. Jim invited questions about last month's discussion and about the Persinger paper about using guilds to evaluate changes in habitat. He asked if there were any questions about how transferable the preferences were.

Question (Q): The Persinger paper discussed how some of the rare species are hard to fit in. How do you tackle issues about these; they are some of the more sensitive species?

Response (R): A lot of rare species are mussels. They had trouble trying to pin down the velocity/depth components for mussels. For mussels it seems to be about whether flow is stable, so critical parts of habitat are covered with water. I don't have a feel right now for how to work with sensitive species. We have done work with Cape Fear shiner, data was collected on physical conditions where they were found. We've done a little work on mussels for generic mussel occurrences in the Eno, not for any listed species. Another approach used for mussels in some relicensing projects was to look at wetted area rather than velocity or depth.

Q: With this particular modeling at a high scale, the dewatering for mussels for FERC relicensing, you are looking if it dewaters quickly, it's bad, etc. How do these predictions play out if looking at monthly average, or weekly?

R: The way we evaluate is to convert a record of daily flows to daily habitat, then analyze by month by a couple methods to compare Flow A to Flow B to Flow C. One metric looks at habitat duration curves. Need to look at all that are greater than 10% and lower than the 90th percentile to cut off the extremes. Roughly it's based on daily flows values for 80 years. Regarding a higher level (larger scale), we're not trying to set conditions for a specific project, we're looking at something to be used in a broad-brushed planning step. The wetted perimeter approach will not get at the stability issue - that is more a hydropower thing, where there may be peaking. We have looked to see if there is a point of inflection below that flow, where we start to see an area not wetted. There is a point of flow where the level is above bank which doesn't provide additional habitat for mussels.

Q: When you add the guild info to the model and seek a measure of certain water flow to the benefit or the detriment of certain guilds, are the models "depletion" models? If you reduce habitat, does it reduce the score? You might deplete habitat for mussel by decreasing flow, but you may increase habitat for another species. How does it look at it?

R: Each guild or species is looked at separately. Referring to Ty Zieglar's presentation in March (slides 51-58 were shown to the group) x-axis was guild, y-axis was habitat parameter. Colored bars represented different flow scenarios; you could scan across 19 species, and see how each species/guild reacts to a different scenario. You can see at a glance a summary of what we are enhancing and what we are depleting. How big are the enhancements and depletions? We look at magnitude and % change, since the % change might not be much if there is not much habitat to start with. It wouldn't take much to lose 70% of habitat, but are you losing much if the guild is not a big part of the ecosystem? In some cases some are better and some are worse. You can look at a month and review all the organisms that were evaluated.

Q: I'm trying to incorporate how that applies to the transects on the river. At each of those transects, it could change.

R: Right. You don't want to merge them together, you would lose nuances.

Q: So we walked the Eno and saw points. It took effort to get the data. If we expand that to understand relationships across the state, how much can we generalize?

R: First we'll try on the Eno to get a feel for what kind of results we are getting. To see if this is promising. We wouldn't base a tentative eco flow for all small flashy streams on just the 2 Eno sites. We'd look at other small flashy sites where we have data, such as one on the Rocky River (sites with data were illustrated on a poster at picnic shelter). If we feel we have enough coverage within a range of stream types, we could look at all of them to see if changing an eco flow recommendation gives you a similar habitat preservation for all of the

sites, or is it all over the place? If the latter, we have to go to plan B. Some stream classifications don't have much data, so we need to acquire more. An example is the coastal plain. We have some on large Piedmont rivers, but just a few. They are more challenging, requiring boats and more field gear. For wadeable streams we have decent coverage.

Q: On the list there are 9 non-fish species. Right now it's not worth the effort to use them, for example "caddisflies" is too general given the diversity of caddisfly species. How much effort will be spent characterizing non-fish communities? It would be a nice effort to mesh the Oasis model with the extensive DWQ database of aquatic macro-invertebrates to get info about the hydrology associated with the sites.

R: We can think about the resources it takes to do it. It's a question of ecological response; loose framework is to first divide streams into distinct types/hydrologic classes, then evaluate ecological responses to changes in flow. One way to get to that is habitat modeling. Another is to look at the actual biological data for streams; see state of biota (fish or other species) in streams with hydrological alterations. The challenge is having before and after flow change data. What was the state of macro-invertebrates before flow changes; was there an addition of flow or reduction of flow? That is the gap I see in NC, there are a lot of data about what bugs and fish are there, but we do not have the historic data for how they've responded.

Q: Some of the sites were thrown out during the hydrologic classification because they showed a change in flow over time. Could those be looked at for biota?

R: Maybe, but if you go back too far you lose the biological data. Is the trend a slow continual change or abrupt change; not sure if one is better? We can think about it.

Q: What are the alternatives to the Eno River model? I'm okay with Eno, but curious about what else is available?

R: We're not throwing out other ideas. Michigan has more biological than habitat data, though they wish they could have used habitat models in addition to the biological data. We have some habitat, data and gap of "before" data for biological data. In 5 years we'll have more bio data in a few isolated places, not state-wide, where hydropower relicensing funded studies. Those flow changes are just starting, so the evaluation will occur in 5 years, and will provide good, but geographically limited data. Another complication for before and after data biological data is isolating flow as a variable for change. If flow has changed due to water supply withdrawal, perhaps there has also been land use change. Is change in biota due to land use change, nonpoint source contributions, or is it strictly because of flow modifications? The tool we have to work with - the law that was passed - is about how ecological flow will react to withdrawals, not land use change.

Q: Regarding wetlands, before and after data can be used to establish reference conditions to see how a wetland changes. But one can also replace "time with space." You could look at a variety of streams with a limited amount of information over time and try to control for

land use statistically, to see how the streams of a similar category change in biota relative to flow conditions.

As an example, with wetlands, you look at a variety of Piedmont riparian wetlands, then characterize and organize them based on characteristics from most to least impacted. This is called a reference domain, and the least impacted sites may be considered reference standard. For wetland mitigation, wetlands that are impacted by human activities may need mitigation. The reference domain is used to determine the amount and kind of mitigation and one strives to mitigate toward the reference standard.

In our case the reference standard is the stream with unimpaired by flow conditions and the subsequent habitat and biota of the particular class of stream. You can go stream by stream and look at before and after conditions (which is problematic since there is limited before-after data). Or you can look at streams of a similar class and look at them as a domain of changes inland use, conditions of flow, etc. These can be characterized into a reference domain with unimpacted streams as reference standards..

R: So, if we looked at all the places with fish & macro-invertebrate data on small flashy streams, hopefully you'd have data points from streams with unimpaired flow. Then you'd pick a flow metric – for example: % change in median monthly flow, cluster another under a 10% change, 20% change, etc. Then test to see if correlation is in diversity or Index of Biotic Integrity IBI. Has Virginia done that?

Comment (C): I don't' know if it was done with macroinvertebrates. They've done it with some fish species (striped bass). It makes sense as a way to tackle the whole question.

Q: If the OASIS model is finished for the Neuse, and we try to use that to come up with the hydrologic parameters associated with biomonitoring sites, could you back track over time since there is 30 years of biological data? There is a rich database on macro invertebrates from the Neuse, it would make sense not as a replacement for the Eno River demo but as a supplement. Sometime you will have to verify it.

R: Research Triangle Institute (RTI) is developing a separate hydrologic model (WaterFALL), which we hope to discuss at a future meeting. It might be a compliment to OASIS.

Comment: A good point; we're trying to find simple surrogates for how biology responds. They don't think like that, simply. Most of the databases have been built over time to evaluate pollution tolerance or intolerance. I've not heard that term brought up much with the EFSAB. In addition to metrics and observations, changes in biology may or may not be related to flow variation or to natural variability of flow. It's an incredibly complex system we're trying to simplify to apply across the state. My concern is that the Eno is only one test; even if it works we may jump to wrong conclusions. We should make our knowledge inferences on more than a single exercise; the potential errors are large. We need to look for a sister evaluation as well.

R: You mean another place like the Eno OR an alternate approach?

C: Ideally you want to have multiple sites with multiple approaches.

Q: We modeled and determined classifications for streams, including small flashy streams (sfs). Can we predict habitat changes in sfs consistently? Does habitat change the same way in sfs consistently across ones classified? Do we know?

R: No. We need to see if it happens across other sites.

Comment: First, it doesn't have to be biological changes; we, need to see if we can predict changes in the Eno, then see if the changes are supported across other small flashy streams. I'd like to know if the classification system holds up from a habitat standpoint.

Q: What measure of change are you talking about?

R: Do we have enough variety in coverage to test this on more small flashy streams? We are doing this on the Eno to try out the process, not to reach a final conclusion. If the process looks promising then cover multiple streams (with geographic separation)to see if we get similar responses from the habitat model to some scale of change in flow (same changes in Eno, Rocky, etc). Then go to western part of the states and look at the many data sites on small stable streams (Little Tennessee, French Broad, etc). We can see if they have fairly consistent change in habitat to the same % change in flow.

The Facilitator asked for other concerns about using this model, or implications of using it.

Q: Is it possible to say we support going ahead and expanding the effort, but not saying it is the one way we'll do it across NC?

R: We want indication that we're not starting down a road that people think is dead-end.

Q: So it is not a no-turning back effort?

R: No.

Q: I encourage you to do invertebrates. If so, you should look at some guilds that have been used more for hydrological investigations than what you have now. For example, in the example for Trichoptera genus, you have netspinning caddisflies, and within this group there are different kinds that do better with high velocities, and low velocities. Within one order it covers the range for hydrologic requirements.

Q: Can you give more info on how these 19 guilds were derived? If you're dealing with the state, in some cases 4 is better than 19. Are we sold on the 19?

R: These were based on a literature review done for the Catawba and Yadkin Peedee Hydropower relicensings. Also, for Western NC, four basic guilds were based on depth and velocity (deep/fast, deep/slow, shallow/fast, shallow slow). Within the 4 there were some variations. These 4 were split based on velocity; for example shallow/fast, was shallow really fast, shallow moderately fast, etc. Some of the other subdividing was based on substrate (for example, deep fast fine, deep fast coarse, woody debris or instream cover). There was not a lot of overlap between slow and fast.

Q: Is it important at a site specific scale and not at the scale we're looking at?

C: We need to look at how things developed over the last 20 years. Back 30 years ago, there was a single species concept used. Since, it's getting away from single species mindset. Starting with the list we formerly used, we stopped thinking of them as a particular species x, but rather a group of species that prefer riffles, for example. This is an evolution. When we go to a site we want to cover the guild stuff, but we also want to look at species x if we have info about it. We'll run those models specifically too. If we started over today, we'd maybe do it a little differently.

Facilitator: What needs to be answered to be able to make a decision? What can be answered afterwards?

C: I think it's important, there is so much variability; we want to capture all inherent variability in the system rather than look narrowly at four coarse categories. Breaking it out like this may help. There may be specific species in mind, but keep it in mind for how a guild applies.

C: We could run Persinger's general guilds through this model as well.

C: From my perspective, this approach seems to be integrated water flow and habitat, without chemistry. If this is a good example of a small flashy stream (sfs) and the primary objective is to see how changes in flow affect habitat that is the first question to answer. Can you do something similar with other sfs and get similar predictable responses? If not, then the rest doesn't matter in terms of finding a method to use broadly across the state.

C: To build on that, we'd like to know better what we expect to get out of the Eno, what we should get if we go to another sfs. What are our expectations, what are we testing against? What is our Null hypothesis? Something to give thought to; no response needed.

Q: Are there other sfs's with similar amounts of transect work done just to get at habitat descriptors, to look at physical aspects?

R: Yes. (Jim showed the map with the sites.)

C: Nobody is saying not to proceed with Eno River. Perhaps we should give a thumbs up here to have it in the record.

The facilitator asked if the group wanted to move forward with the Eno River demo with your reservations, or set it aside for something else.

C: I'm hearing from the EFSAB to move forward with the Eno site in addition to a sister site. I'm concerned about not putting all our eggs in the Eno basket. Use Eno as catapult to look at other issues statewide. Whatever we do on Eno, couple it with sister site or test cases to see if Eno data is trustworthy at some other location. Granted we can't test it at 50 other sites (ideal), but we don't want to test our approaches or knowledge, info gained at only one location. That is not a good statistical example. A poll sample of 1 can be very misleading (need at least 2 to draw a straight line).

C: The way Jim portrayed the proposal was not to just look at the Eno River demo, it's not this or nothing.

C: Part of the problem is that we have not looked beyond the Eno. Primarily we've been talking about applying it across the state.

Q: As the EFSAB, when will we get to more contentious issues; going from a few sites to a spatially extensive network is always difficult. When will we deal with that thorny issue?

Facilitator : We can discuss that for the July agenda. Can you decide to move forward with the Eno River model while also determining what else needs to be done (sister site, for example)? Can DWR continue looking at the Eno model?

Q: What is our measure of success for looking at the Eno River model? What are our criteria for success?

C: Our objective is to have data to look at. Our objective is to have results from a typical or example stream, something for us to dig through and say whether it makes sense or not.

C: I'll add to that and that there may be a need to also do another site and compare similar data.

C: It may be necessary to run the Eno once Eno to see that it's working, then look at and determine a sister site.

C: DWR has clearly heard the discussion and concerns, we need to leave them some flexibility, whether they will move forward with Eno alone or sister it up with other concepts.

Facilitators : DWR needs direction from EFSAB.

C: Perhaps hear what DWR is going to do in the next few months.

C: What are our expectations for the Eno? The expectations are how things change at Eno. The only way to discern how it works is to have a second site. We haven't seen actual sampling protocols for biology. Are our expectations too simplistic?

Q: There is not biological sampling - this is based on habitat modeling. Are we validating it with biology?

R: One validation process would be to come up with habitat results and then see if fish and bugs are where model says they should be. We don't have plans to do that due to resources required and not sure we can get them. It's not impossible to do if you have the time and resources.

I want to respond to expectations about the demo project. First, the Eno demo is not one site, it is 2 so we can draw the line. There are 2 sites on the Eno. Our expectations on the demo are limited. I'm hoping it will help us decide what are the metrics that are important in the model outputs: is it the monthly?; are the 19 guilds good?; too many, too few?; is it a % change in habitat index? To come up with the nitty gritty questions about how to analyze the data. They will be easier to answer if there are some real results to get into it. Prime expectations are to refine our questions before going to next sfs sites to see if we get similar results.

Proposal: Does group feel DWR should move forward with demo effort for the 2 Eno River demo sites to produce results and make sure we're analyzing those results correctly? DWR can likely get results in 2-3 months.

I've heard other good comments - about using historic data on macro-invertebrates, and using OASIS to look at flows. Use OASIS to look at groups of streams (small flashy streams in the Neuse for example) with no change, hydrologic alterations, and look at if their ratings by NCDWQ macro invertebrate standards. We would have to look at available resources for that approach. Currently my proposal is for the 2 Eno River sites while considering the DWQ data separately.

Q: No biology? (Clarification on proposal)

R: No. The biology is literature based on how the species and guilds respond to changes in flow. Would need to spend more time thinking about what would be involved in pulling up DWQ bug sites and trying to sort them by degree of flow alteration.

C: I would start with a reference site.

The facilitator asked the group to respond to a 5 –finger consensus poll on the proposal. Results of the poll (rank-votes): 1-8, 2-2, 3-3, 4-0, 5-0. Since there are no 4's or 5's, DWR will move forward with it.

V. Revisit Scope of EFSAB Work

Division of Water Resources would like to clarify the scope of the EFSAB and its legislative mandate, especially in relation to some of the issues that have been raised at previous meetings. Two main points are:

3. High flows. It is reservoirs that impact high flow regimes. It isn't the water taken out of streams that impacts high flow; it is this big pool in reservoirs. We can acknowledge the importance of high flows to stream ecology, but not use them to determine flows for ecological integrity. Run-of-river withdrawals and low flow scenarios are more appropriate to the scope of the legislation. Reservoirs are more suited to case specific permitting as opposed to the planning process the EFSAB is trying to develop.

4. Land use change. It has a huge impact but it is not a part of the legislative mandate for determining ecological flows.

Comments:

- Regarding high flows and withdrawals, we need to be concerned about cumulative effects.
- With significant withdrawals, the cumulative impact on high flows may be disregarded if you aren't looking at high flows.
- It isn't EFSAB's responsibility to look at flow recommendation. Instead we are charged with reviewing the proposals DWR puts forward.
- If we put a lot of effort into coming up with ecological flows, we can't just say that it won't work if there are changes in land use or development of new reservoirs. We may need to say that if you do develop this land, specific changes will take place to ecological flows.
- We should include land use in the modeling since available water depends on land use.
- Land use issues should not be the focus of the EFSAB.
- We need to define when a reservoir is a run of river reservoir and when it is separate.
- Total water use in the state is an issue.
- When looking at withdrawal impacts, you need to look at cumulative impacts. You should also be looking at reservoir withdrawals. It is in no means our charge to look at flow recommendations; it is our charge to look at reviewing the proposed model approach that DWR will put forward. It is not our charge to look at social concerns; that is a policy approach.
- We are putting a lot in to this and then saying, if you develop the land, none of this is going to work, if you put in a reservoir, none of this is going to work. We need to go a little beyond being totally focused only on water supply or I'm not sure this will be all that useful.

- If we want this to be useful, these things need to be included.
- We would be lacking if we didn't try to include some of this in our approach, but it can't be all consuming. In the end we may need to encourage DWR to include these things in their decision making at the end.

DWR response:

- DWR should try to include land use and its effect on ecological flow in the hydrological modeling, in terms of predicting future conditions. In terms of water availability, for water supply and instream, we need to have an idea of total water availability under future land use conditions. So we need to be able to accommodate that in our model from the standpoint of how much water is there to work with. If we did not do this we would be lacking in our approach.
- Incorporating land use information into the modeling is a good idea but making recommendations about how land use should be managed is not.

Board Members heard that DWR had to operate during the EFSAB process with the following limitations, but did not determine how these limitations would be addressed in the EFSAB process.

- Acknowledge the effect of high flows on ecological integrity but focus on the impacts of water supply and water withdrawals on ecological flows.
- Acknowledge land use but focus on the impacts of water supply and water withdrawals on ecological flows. Attempt to incorporate future land use conditions in modeling water available for instream and offstream use.

VI. What Does Ecological Integrity Mean to You?

The legislation that mandated the formation of the EFSAB tasked the EFSAB with assisting the Department of Environment and Natural Resources (DENR) in characterizing the ecology in the different North Carolina river basins and identifying the flow necessary to maintain *ecological integrity*. The legislation defines ***ecological integrity*** as **"the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to prevailing ecological conditions and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system."** Although the legislation provides a definition, and the EFSAB must work with that definition, different EFSAB members may have different interpretations of that definition, and members may have differing views and opinions on what *ecological integrity* encompasses. In order to increase understanding among the EFSAB members of how they look at and interpret ecological integrity, as they work toward reaching consensus in identifying the flow necessary to maintain ecological integrity, the

facilitators invited the individual EFSAB members to consider how their own definition of ecological integrity might differ, if at all, from the legislative definition. Members were given time to write responses on cards. They were invited to share their responses with the group, and the cards were collected. The responses included:

Disruption/Recovery

- I concur with the definition with an exception being the "absence of a recovery timeline". What is an acceptable recovery period? Left up to interpretation, this provides lots of wiggle room that potentially weighs against the aquatic community.
- How much "disruption" can occur that still allows recovery?
- Promote and maintain an aquatic system that thrives on its existing environment and can adapt to change within limits of disruption without extreme negative impacts.
- The condition where the health of a system is balanced and is able to withstand and recover from temporary variances of its various components.
- "recover" from disruptions—NC aquatic systems will confront major changes due to changing land use, climate, etc. I don't think it makes sense to seek a recovery to a previous state, but instead manage systems so that they can **change** in ways that allow them to maintain diversity, ecosystem functions, etc. It's not about looking backwards, but about coping with what is coming.
- Resiliency—(recover following disruption)—not currently addressed in EFSAB thinking. How to assess this capacity? Costs? Resource intensive.
- Demonstrate resilience.
- The definition should stop after "prevailing ecological conditions", as the remainder is not clearly defined relative to the source of the disruption.
- The subject of hysteresis.

Prevailing Ecological Conditions

- What is the baseline to use in evaluating the effects of flow modification? This needs to be clarified. Are the large storage reservoirs (e.g. TVA, Corps of Engineers, power companies) and their **existing** operation the baseline for the river downstream of the dam?
- "Comparable to prevailing ecological conditions" is not from the Instream Flow Council book's definition, but added by the legislation. What does that phrase mean?
- Prevailing ecological conditions—time period—years, months, day(s)? Best or worst over time period?
- "Comparable to prevailing ecological conditions" is fuzzy.
- What does "comparable to prevailing ecological conditions" mean?

Balanced

- What is meant by "balanced"? Hopefully not equilibrium, which I don't think systems achieve, nor will they in the changing environment we live in.

- Take out or define "balanced" since no "natural" system is ever in complete "balance".
- Ecological integrity is when health of a system Is balanced.
- I would not have included balanced because it implies stasis and no system is static.

Complexity

- "Complexity" is an important component of integrity, from organismal complexity across the food web, to structural complexity, etc., all of which contribute to a system's ability to respond to perturbations.
- Ecological integrity should account for complexity and for variability in many aspects: thermal, hydrologic, biologic, etc.

Determining Factors

- What if flow is not the determinant factor supporting ecological integrity in a particular classification of stream? Should this be determined?
- Flow is not the only issue.

Natural

I disagree with the last phrase of the definition: "continue to provide the natural goods and services that normally accrue from the system." This is too artificial and human-centric. It should be approximately the natural function and processes of the system.

Not Just Aquatic Systems

Ecological integrity is not specific to just aquatic systems. It includes the entire ecosystem—both aquatic and terrestrial—and includes both biotic and abiotic components and processes.

Monitoring

Who is charged with "monitoring? Or making the determination that ecological integrity is being adequately protected?

Functional Organization

Function (fish) vs. Guilds (bugs)—How defined? Have we addressed this? Do we have common ground on what constitutes "functional organization" as re. integrity?

Goods and Services

Specify what is important—water supply? WQ [water quality] (not currently considered)? Energy/material cycling (not currently considered)?

VII. Flow Scenarios

Chris Goudreau of the NC Wildlife Resources Commission presented an Introduction to Flow Scenarios. Chris's slideshow can be found online. The presentation was followed by discussion and decisions about future flow studies.

Presentation: Introduction to Flow Scenarios

The level of flow protection on any given stream can range as follows:

- No Protection - No legal ability to keep from drying up the stream. This is rare in NC, but there are examples.
- Threshold Protection / Minimum Flow - This may be a single value, such as the 7Q10 or it may be a seasonal value (e.g., 20/30/40 percent of MAF)
- Partial Ecologically-Based Protection - This addresses 1-4 riverine components. There are 5 components: hydrology, biology, water quality, connectivity, geomorphology. The most likely to be addressed in this scenario are hydrology, biology and water quality. In addition, this scenario may address intra-annual variability, but not inter-annual variability.
- Comprehensive Ecologically-Based Protection - addresses all 5 riverine components and maintains intra-annual and inter-annual variability.
- Full Protection (hands off) may be seen in wilderness areas or other things that are set aside for other reasons.

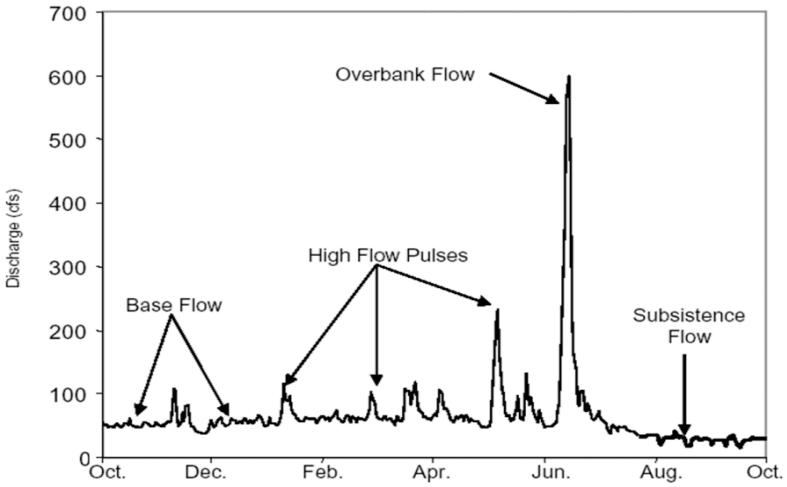
General Approaches to Providing Ecological Flows (Richter et al. 2011)

- Minimum Flow Threshold (basically the 7Q10 concept)
- Statistically-based Standard
- Percent of Flow Standard

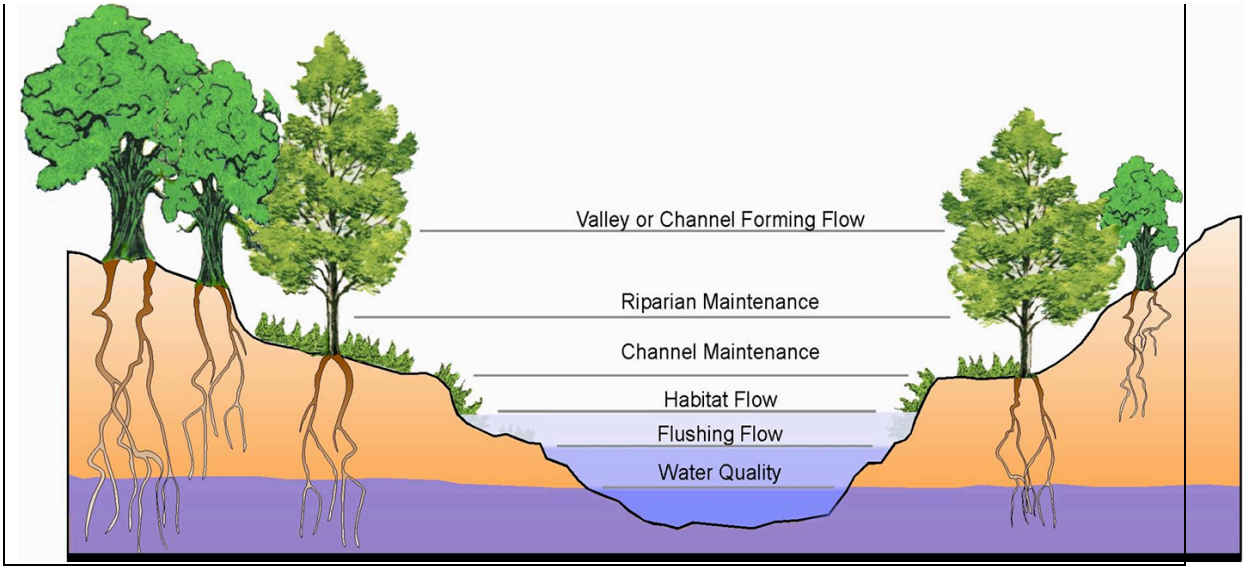
Statistically-based standard typically affords partial protection, but could be comprehensive. Statistically-based standard flow components should include: Critical low, low, high flow pulses, small floods, high floods - for wet, normal, and dry years. It includes the magnitude, duration, frequency, and season for each. It is also tied to ecologically significant events such as: spawning, floodplain rejuvenation, fry/juvenile growth, migration, sediment movement, channel maintenance.

Annual hydrograph identifying flow components.

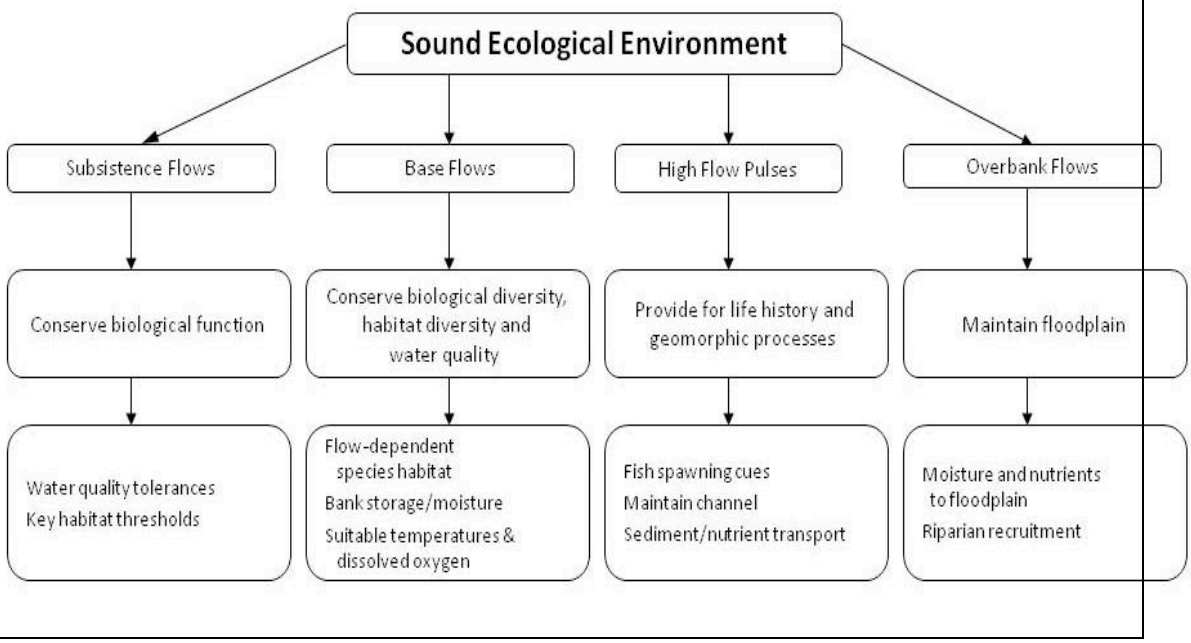
This is the level of detail required for developing a flow standard. In addition, multiyear data is required to determine if it was an overall wet, dry, or normal year.



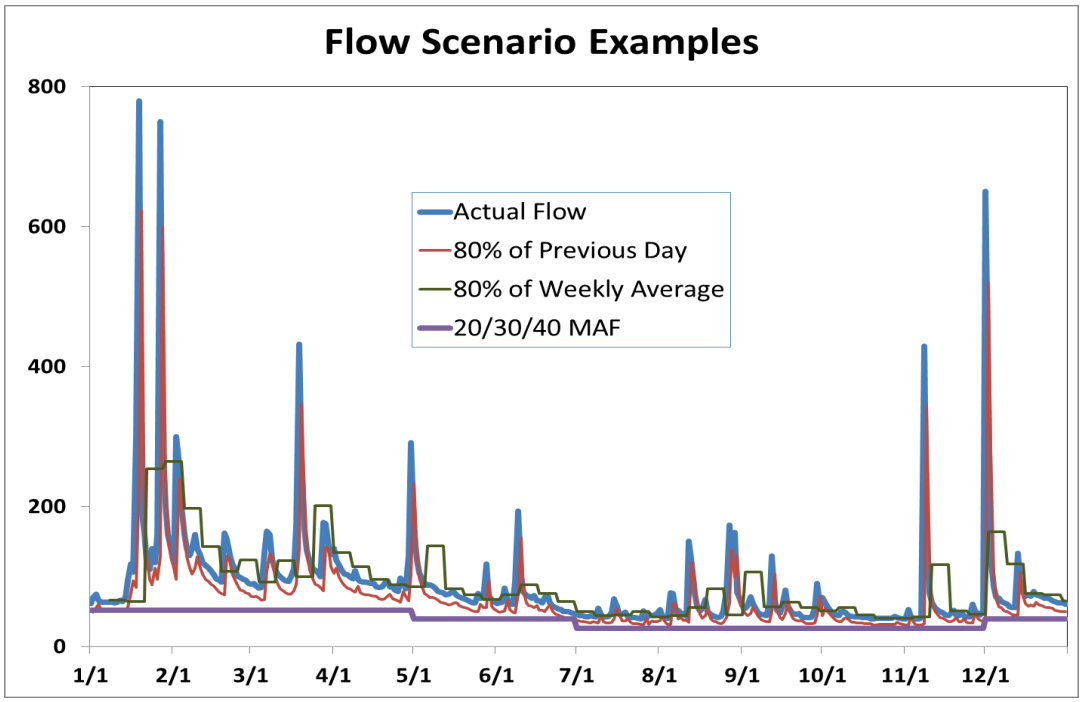
Cross section of stream identifying flow depths



How flow regime is tied to ecology



Percent of flow standard is where a certain amount of water is left in the stream (or removed from the stream) over a given time period. There are many examples of withdrawing between 6-20% of the annual flow (Richter et al. 2011). The time period may be daily, weekly, etc. and the withdrawal may also vary by season.



Discussion:

What feedback do you need?

Question – Question (Q): Can you reiterate what will be the most meaningful example of what feedback we can give you?

Response (Answer –R): DWR is going to run the Eno River flow model and it will give us data on how the Eno River responds to various flow standards. We can then question whether we expect this to happen in other streams of this type. DWR will run the habitat model under different flow regimes simulated by the Oasis model, analyzing the habitat response for each flow regine.

The EFSAB needs to help DWR determine which flow regimes to run.

Examples of flow regimes include 7Q10, percent of inflow removed, and percent of flow retained in stream. The percentage could be based on total ambient inflow, or based on previous measurement, or based on mean annual flow.

It was noted that many of the factors such as spawning data is not germane to the habitat model the EFSAB will be using.

Comment (C): SC has decided on 20, 30, & 40 % of average annual flow. The percent is dependent on the season. When it says 20%, it means an amount equal to 20% of the flow statistic will be left in the stream.

C: It is intensive to run the model, but DWR will be running as many as needed, within reason.

Q: A model output that tells me what 20% of water left in a stream looks like, doesn't necessarily help me evaluate ecological integrity.

R: The output is by transect. Think of the cross section of a stream. The output will tell us how much area is covered by how much water and what it is next to, such as a deeper area or a more shallow or waterless area.

Q: Is there a measure of species diversity that can come out of this model?

R: We use the habitat curves as a surrogate for the biology. We make assumptions and say, this type of habitat supports this type of biota.

It may be that when everyone sees the output from running the model, there may be a better understanding of what we can be assumed, posited and ultimately decided about habitat and ecological integrity.

C: It is important to know the changes in the graph, the thresholds where things change. If the outputs are all linear graphs, it is easy to make assumptions. We need to know at what flow regimes things change.

C: The 7Q10 is such an old standby that we need to include it as one of the inputs.

Q: What other options are there for us to measure? Can we measure temperature?

R: No, temperature is not an option. Chemistry is not an option.

Q: Is rainfall an option?

R: Stream gauge data is used to determine flow in the stream. If a stream gauge is not available, rainfall data is used to determine the flow.

Q: What about the source of the water, for example, wastewater discharge may account for a large portion of flow during dry seasons?

R: Water sources will not impact the model output. Once we have the baselines from the model, we can then consider additions from different sources.

Q: Is the amount left in a stream, the reverse of the amount taken out of the stream, for example, is 20% left in the stream, the same as 80% taken out.

R: No, because when discussing how much you take out on any given day, it is based on the most recent measurement, whether it is daily or weekly, etc.

Q: Do we need to measure only realistic withdrawals?

R: We can leave realism to the policy makers.

Initially, we will not adjust the model based on seasons. We will look at months.

Following the presentation and discussion, a decision was made to run the following flow studies in preparation for future meetings:

1. Minimum flow equal to a percentage of average annual flow (MAF). We will look at 10, 20, 30, 40, 50, & 60 percent of MAF. [This incorporates some of the approaches used by SC and GA.]
2. Minimum flow equal to annual 7Q10. [A drought flow used for wastewater discharge assimilation and effluent limits in discharge permits.]
3. Withdrawal limited to a percentage of ambient flow. We will look at 10, 15, 20, 25, & 30 percent. For the initial evaluation we will let the model adjust withdrawals on a daily basis, but a more realistic approach for implementation would adjust them once or twice a week. [Approach used by City of Charlottesville, VA.]
4. Minimum flow equal to monthly 7Q10 – a different flow for each month. [Approach similar to one of three options used in GA.]
5. Monthly minimum flow equal to the monthly median flow.

6. Minimum flow, year-round, equal to the September median flow. [Approach similar to one option used in TN.]

VIII. Agenda for next meeting

The EFSAB will meet in August at RTI. The agenda includes:

- learn about the WaterFALL model and how it may integrate with OASIS
- review and discuss the timeline of the Ecological Flows Science advisory board
- review an example flow scenario run with the OASIS model for the Eno River

IX. Directions to August 16 Meeting at RTI International, 12 noon

We will meet in the 09 Building on the RTI Campus. (Letter T on the map.) You can park in the deck across from the building. The campus is located at 3040 Cornwallis Road, Research Triangle Park, NC 27709-2194.